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1 Introduction

The interplay between psychology and politics, not economic cost-benefit analysis, has been the key driver of real-world climate policy, and the consequences are unsettling. Actual policies have been more in line with business-as-usual behaviors than with the recommendations made by most mainstream climate scientists and economists. Why psychology and politics have combined to produce this state of affairs is what I call the "big behavioral question."

The psychology of climate change centers on fear, bias, and hope. In a nutshell, fear relates to the kind of future damages that global warming will bring. Bias is about misjudgments and misplaced emotions that hamper the global community from appropriately responding to climate threats. Hope is about the potential emergence of new technologies that might significantly reduce greenhouse gas (GHG) concentrations to sustainable levels in a timely manner at reasonable cost.

1.1 Drivers of the Global Community's Response to Global Warming

Fear, bias, and hope have driven, and will continue to drive, the global community's response to global warming.[1] There is plenty to fear. Thus far, the global community's reaction to most mainstream climate scientists' global warning prognostications and alerts has been too little, too late. The global community has also ignored policy recommendations from mainstream environmental economists about putting incentives in place to induce abatement behavior. While there are many ways to address global warming, business-as-usual behavior is not one of them. Yet, for the most part, over the past four decades global GHG emissions have pretty much followed a business-as-usual trajectory. This is unsettling.

Pitfalls stemming from psychological biases have played a major role in explaining why the global community has resisted the advice from mainstream climate scientists and economists. This is unsettling. Examples of pertinent biases are present bias, confirmation bias, excessive optimism, and overconfidence. Among these, I would single out self-control issues related to present bias, whereby the needs of the present are accorded excessive importance relative to the needs of the future. While we cannot turn back the clock, the community needs to understand biases and their impact on climate policy in

[1] I made this point in Hersh Shefrin, *Ending the Illusion of Management* (New York: McGraw-Hill, 2008). The focus of the book was on the psychological dimension of organizational decision-making, and the factors that distinguish organizations that act in psychologically smart ways from others.

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order to behave more sensibly going forward. Until the community accepts this reality and successfully addresses it, these biases will continue to contribute to climate havoc.

There is hope for sensibly addressing global warming and restoring GHG concentrations to sustainable levels. Hope rests in the development of nascent technologies for removing GHGs from the atmosphere at reasonable cost. Given the psychological biases preventing the institution of cost-benefit–based emission abatement policies and more investment in adaptation to rising temperatures, the global community will need to rely on GHG removal technologies.

My message of hope for the future needs to be tempered with caution: call the combination cautious hope. The community needs to understand how biases have the potential to reduce the benefit of GHG removal technologies, and the community needs to be prepared to mitigate the potential negative effects from psychological biases.

To identify the impact of fear, bias, and hope on global warming, I focus on three elements. These are:

1. the warnings from most mainstream **climate scientists** about anthropogenic global warming during the past four decades;
2. the prescriptions from economic **integrated assessment models** about cost-benefit–based responses to the threat posed by anthropogenic global warming; and
3. actual climate policy developed in the **political arena**, including the impact of special business interests.

Next I offer comments about each element in turn.

1.2 Climate Scientists

Beginning in 1979 climate scientists provided a coherent analysis of the risks associated with anthropogenic global warming. I use the term "risks" here because these scientists were clear about which statements they were confident in making and which not. In respect to their most important assertion – about the relationship between global temperature and emissions of carbon dioxide – they provided confidence intervals.

People who routinely set unduly narrow confidence intervals are said to be overconfident about their knowledge. More than forty years later climate scientists' key confidence interval has withstood the test of time, suggesting that they were *not* overconfident in their associated judgments.

This is important, as for years climate skeptics maintained that the science underlying global warming is "unsettled." The "unsettled" contention is itself

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unsettling. Scientific claims are rarely 100 percent settled, so the "unsettled" issue is not germane. Rather, the point is that the science underlying global warming is sufficiently settled to move forward with cost-benefit–based climate policy, with which past policies have been inconsistent. Just to be clear: more than two-thirds of anthropogenic cumulative emissions of carbon dioxide into the atmosphere have occurred since 1979.

1.3 Integrated Assessment Models

Integrated assessment models (IAMs) provide a framework for analyzing alternative economic policy responses to deal with anthropogenic global warming. Economist William Nordhaus developed the first IAM during the 1980s and 1990s, and named his framework the Dynamic Integrated Climate-Economy (DICE) model.[2]

I use DICE as a vehicle for identifying key behavioral issues associated with climate policies. In this respect, Nordhaus identifies two specific policies, one representing business-as-usual behavior and the other representing an optimal response to global warming. I treat the first policy as reflecting the theoretical impact of psychological pitfalls relative to Nordhaus' optimal policy.

There has been wide disagreement among economists about Nordhaus' choice of parameter values and functional forms for computing the optimal solution. Some economists, most prominently Sir Nicholas Stern, propose a much stronger climate policy than Nordhaus' optimal policy.

I will discuss the associated debate in some detail, but at this stage I want readers to understand the following point. Over the course of the past four decades, carbon dioxide emissions have been much closer to the trajectory in Nordhaus' behavioral business-as-usual case than his optimal case. The gap is that much wider for the optimal paths associated with alternative IAMs offered by other economists. This is unsettling.

All of this is to say that when it comes to the formulation of economic policy, policymakers have paid little heed to the recommendations made by eminent economists. This, I suggest, is the result of psychological bias.

The term "neoclassical" can be loaded. The economics profession uses it to characterize the mainstream approach of modeling economic choices as the

[2] The DICE model is developed in William Nordhaus, *Managing the Global Commons: The Economics of Climate Change* (Cambridge, MA: MIT Press, 1994). Further elaboration can be found in William Nordhaus, with Paul Sztorc, *DICE User's Manual*, second edition, 2013. https://tinyurl.com/5n6zwua3. Also see the dicemodel.net website. Information about the 2016 version of the DICE model can be found in William Nordhaus, "Revisiting the Social Cost of Carbon," *Proceedings of the National Science Foundation* 114(7) (2017), 1518–1523. www.pnas.org/doi/10.1073/pnas.1609244114.

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outcome of rational decision-making; this is how I use the term throughout this Element. I understand that some readers might use the term more broadly – for example, as a label for a libertarian-based approach – but my definition is narrower.

Nordhaus constructed DICE as a neoclassical framework by introducing climate equations into the production sector of a traditional aggregate growth model. His model features a representative agent/social planner, meaning that the economy behaves *as if* all agents/consumers have the same preferences. The optimal case corresponds to the representative agent engaging in maximizing behavior, which is to say that the representative agent behaves rationally.

There is a tradition in the neoclassical approach of explaining real-world choices through the use of a rational representative agent. Consider two points about this tradition. The first is that the underlying aggregation approach rests on very shaky theoretical ground. The second is that neoclassical assumptions do not capture key psychological aspects of the way real-world individuals behave, especially in respect to intertemporal choice.

The aggregation assumption is that equilibrium can be described as if all agents share the same beliefs and preferences as some average agent, called the representative agent. This is the case even when there is considerable diversity among individual agents in respect to time preference (meaning degree of impatience), risk tolerance, and probabilistic beliefs about different risks. Most importantly, the neoclassical assumption holds that the representative agent is rational. In particular, the representative agent exhibits maximizing behavior, does not change their mind over time, has a stable attitude toward risk, and holds coherent, unbiased beliefs about the risks being faced. By coherent, I mean the holding of consistent conditional probabilities over time.

The neoclassical rationality assumption is heroic. In the general case involving agent diversity in respect to time preference, risk tolerance, and beliefs, the representative agent associated with an equilibrium will not be rational. Instead, the representative agent typically exhibits strong behavioral features. Specifically, the representative agent will be dynamically inconsistent in the sense of wanting to change their mind over time, have an unstable attitude toward bearing risk, and hold biased incoherent beliefs about the risks being faced.[3]

There is a point here about what I call "excessive rationality-assumption bias" in economic modeling. When psychological pitfalls are strong, neoclassical models that exhibit excessive rationality-assumption bias are prone to be misleading.

[3] See Hersh Shefrin, *A Behavioral Approach to Asset Pricing*, second edition (Boston, MA: Elsevier, 2008).

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Keep in mind that the concept of a representative agent is an analytical device for analyzing prices and aggregate quantities. In Nordhaus' DICE model the representative agent plays two roles. The first relates to driving private-sector decisions about consumption, saving, and investment. The second relates to public policy about pricing carbon dioxide emissions, which is typically achieved using either a carbon tax or a cap-and-trade system.

Nordhaus constructed DICE to feature two sets of controls, one relating to saving rates and the other to the price of carbon (dioxide). Both of these control variables involve self-control issues featuring present bias, the "unwarranted" overweighting of the present relative to the future. There is certainly a large economics literature on the topic of insufficient saving, and in this Element I will analyze present bias issues associated with pricing carbon.

Nordhaus constructed DICE so that the optimal case produces saving behavior and rates of return on capital that are in line with their respective historical rates. In practice, these historical rates have been relatively stable over time. Whether or not past saving rates qualify as being optimal, there is reason to have confidence that the output from DICE would feature reasonable predictions of saving rates in the future.

The situation with outputs from DICE for carbon prices is another matter. Real-world carbon prices have been significantly less than the "optimal" values generated from DICE. I attribute the gap between the two to present bias associated with a lack of self-control and related psychological pitfalls. Critics of DICE have raised questions about parameter values or functional forms associated with the relationship between damages and atmospheric carbon dioxide concentrations. These are certainly important. However, they miss the important point that DICE fails to capture the psychological pitfalls associated with the political processes that determine the choice of carbon prices and related abatement activity levels.

From a psychological perspective, neoclassical economic models are crude. While consumption/saving decisions and carbon pricing decisions both involve intertemporal self-control issues, neoclassical models fail to capture important nuances differentiating the two. Behavioral economists emphasize that many factors influence self-control, which cannot always be boiled down to a discount rate reflecting time preference and an associated maximization. The difference between saving behavior and emissions abatement behavior is a case in point. This difference is an important issue that I address in this Element.

Similar statements apply to risk. Rather than positing that risk preferences can be captured by a parameter associated with risk aversion, as is the case with

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the neoclassical approach, the psychology of risk focuses on the way attitude to risk varies across circumstances.[4] This difference is also a topic I address in this Element.

Being a model, DICE is like a heuristic, and a valuable heuristic at that. In terms of structure, it does not capture all the important elements associated with climate policy, but it does provide a robust vehicle for engaging in a systematic discussion about key policy issues. Certainly some of its assumptions about parameter values and functional forms are questionable, but discussing debates about these assumptions provides an opportunity to highlight other critical issues. Being a neoclassical model, its treatment of key psychological elements is crude, but it provides a good starting point for a discussion about which psychological elements are missing and how these missing elements might impact key conclusions from the model.

Although I devote a lot of space to discussing DICE, I want to emphasize that this Element is not primarily about IAMs. It is about the psychology of global warming. Of course, I will discuss weaknesses in DICE and how more recent IAMs have addressed these weaknesses. However, my main reason for doing so is to bring out important psychological issues. These are issues that for the most part neoclassical IAMs miss.

Collectively, IAMs provide a broad range of cost-benefit–based global policies for addressing the threats posed by anthropogenic global warming. Operationally, "cost-benefit based" means a solution to a specific social planning optimization problem. For several reasons, the range is broad, not the least being the amount of uncertainty being faced.

With this said, remember that real-world emissions behavior has been much closer to business as usual than to any of the optimal trajectories from IAMs. Thus far, IAMs might be normative, but they have not been remotely descriptive.

Economists might be speaking, but global decision makers have not been listening, at least when it comes to climate policy. Moreover, developing IAMs with increased complexity is unlikely to lead global decision makers to listen

[4] My papers with Richard Thaler on self-control contain the first formal exposition of the two-system thinking fast and slow perspective Kahneman popularized in his outstanding 2011 book. See Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus, and Giroux, 2011). Thaler and I first presented our framework to Kahneman and Tversky in February 1978, when two-system thinking was not part of their approach. Thaler and I called our framework "the planner-doer model," which I maintain provides a better description of the action-based tasks associated with the two systems. It begins with thinking, but it is more than thinking, as thinking gets translated into action. Thaler and I designed the planner-doer framework to analyze self-control issues in economic decision-making. When in 2017 the Nobel Committee presented the award to Thaler in Stockholm, they emphasized our work on the planner-doer model and the way it integrated the major themes in Adam Smith's two major works, connecting them through modern behavioral economics.

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more intently to what economists prescribe. More facts and theories are unlikely to make a difference, because the underlying impediments are not for the most part rational: they are psychological.

1.4 Politics

Real-world emissions behavior is the result of decisions made in the spheres of politics and business. Political outcomes are not easily described as optimal policies resulting from choices made by a rational benevolent social planner. In many ways, diversity, meaning heterogeneous beliefs and preferences, operates on political decisions as it does on economic and financial decisions. Political decisions might resemble the outcome of a representative social planner, but this planner exhibits strong behavioral features such as dynamic inconsistency of preferences, biased judgments, and incoherent probability beliefs.

I will make the case that heterogeneity has been a major factor in American climate policy, beginning with the response to the concerns expressed by mainstream climate scientists during 1979. At that time the United States was the largest annual emitter of carbon dioxide into the atmosphere, followed by the Soviet Union. By 1991 the Soviet Union had disintegrated and was subsequently replaced as the second largest emitter by the countries making up the European Union (EU).

On a cumulative basis, the United States has been the leading contributor of carbon dioxide emissions, having emitted about 417 billion metric tons (as of 2021). The EU is second, having contributed about 367 billion tons. Next comes China, which contributed about 238 billion tons.[5]

Notably, as China successfully grew its economy during the past three decades, its carbon dioxide emissions soared. In contrast, the United States and the EU managed to slow their emissions to the point where both had peaked by 2007. Thereafter, on an annual basis, China became the world's largest emitter of carbon dioxide. This has been a major reason why the global community has continued to follow business-as-usual behavior.

More information is available about global warming political dynamics in the United States than in China. For this reason, I concentrate on the experience of the United States, especially the role special business interests played in preventing the passage of cost-benefit–based climate regulation around carbon taxes and cap and trade. However, since 2006 it is China more than the United States and the EU that has played the bigger emissions role; going forward, it is likely that India and other developing countries will join China in this regard.

[5] Before 1989 EU emissions were larger than those from the United States, but the nations currently making up the EU did not constitute a single political entity.

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Developing countries can rightly feel that they should not be doubly penalized. They contributed only minimally to cumulative GHG emissions, but disproportionately suffer the impact from past emissions by the developed world, and they ask why they should now be prevented from improving the material living standards of their populations, which lie well below those in the developed world. An important part of climate finance involves investments and wealth transfers from the developed world to developing countries. The magnitude of these investments and transfers will to a large extent be determined in the political arena, and these will be critical for future global emission rates.

1.5 Synopsis

In concluding this section, I note that readers who are interested in a synopsis of what follows can find a short summary in the appendix to this section.

2 Fear Based on Scientific Models of Global Warming

Fear is an emotion that people and animals feel when they sense danger. Fear is typically a response to a stimulus, an alarm warning, suggesting a potential threat.

Typically fear heightens attention to surroundings, inducing a search for threats, an evaluation of the magnitude of potential threats identified, an assessment of possible fight-or-flight responses, and the transmission of an alert to the motor cortex to prepare for an imminent response if necessary.[6]

In this section I describe some of the early scientific work investigating what global warming is and what climate scientists suggested that there is to fear. This discussion will set the stage for future sections about the global community's fight, flight, or freeze response to warnings about global warming.

For behavioral reasons, most of the time I choose to use the phrase "global warming" in place of "climate change." This is because, in 2002, political consultant Frank Luntz recommended the reverse to President Bush, meaning that "climate change" should be used in place of "global warming." Luntz's recommendation was intended to blunt political support for reducing carbon emissions. In a memorandum to the president, Luntz wrote:[7]

> It's time for us to start talking about "climate change" instead of global warming . . . "Climate change" is less frightening than "global warming." As one focus group participant noted, climate change "sounds like you're

[6] Physiologically, fear involves the activation of the amygdala followed by a change in hormonal balance, with an increase in steroid hormones such as adrenalin, cortisol, and testosterone.

[7] Frank Lutz, Memorandum to Bush White House: "The Environment: A Cleaner Safer, Healthier America" (2002). www.sourcewatch.org/images/4/45/LuntzResearch.Memo.pdf.

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> going from Pittsburgh to Fort Lauderdale." While global warming has catastrophic connotations attached to it, climate change suggests a more controllable and less emotional challenge.

Luntz's remarks, especially about "emotional challenge," clearly pertain to the psychology of fear. In this regard, I would highlight two psychological concepts, "framing" and "affect markers," that are relevant to his remarks. "Framing" is a term that psychologists apply to how issues and decision tasks are described, and they emphasize that changes in framing alone can impact the choices people make.[8] "Affect" is a term that psychologists use to describe emotions, positive or negative, and how strong they are.

The reframing of "global warming" as "climate change" was psychologically powerful and contributed to global emissions following a business-as-usual emissions trajectory.

In respect to Luntz's phrase "catastrophic connotations," consider what scientists had been saying about global warming during the prior twenty-five years, beginning with a major report released in 1979.

2.1 The Charney Report, 1979: Cause for Concern

In 1979 the US National Academy of Sciences issued a report entitled "Carbon Dioxide and Climate: A Scientific Assessment." This report came to be called the Charney report as its team of authors was led by Jule Charney, a highly respected meteorologist from the Massachusetts Institute of Technology.[9] The concern about anthropogenic global warming was not new, but before the Charney report there had been no systematic approach to study it. Moreover, at the time some scientists had proposed an opposing theory – global cooling stemming from anthropogenic aerosol release.[10]

The Charney report was delivered to the Climate Research Board, the Assembly of Mathematical and Physical Sciences, and the National Research Council. Its message to these bodies was stunning and stark. The world had something to fear: growing global warming resulting from high emissions of carbon dioxide into the atmosphere, which occurred when humans burned fossil fuels.

[8] Amos Tversky and Daniel Kahneman, "The Framing of Decisions and the Psychology of Choice," *Science* 211(30) (1981), 455–458.

[9] Jule G. Charney, Akio Arakawa, D. James Baker et al., *Carbon Dioxide and Climate: A Scientific Assessment. Report of an Ad Hoc Study Group on Carbon Dioxide and Climate. Woods Hole, Massachusetts, July 23–27, 1979* (Washington, DC: National Academy of Sciences, 1979).

[10] For the history leading up to this report, see Nathaniel Rich, *Losing Earth: A Recent History* (New York: MCD, 2019). Rich also describes the concern about aerosols inducing a new ice age. Jule Charney, the lead author of the report, has been described as the "father of modern meteorology."

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The mechanism the Charney report studied is straightforward and relatively easy to describe and can be likened to the way a greenhouse is used to trap heat in order to grow plants. This analogy led to the term "greenhouse effect" being applied to global warming.

Solar radiation passes through the Earth's atmosphere unabsorbed because of its frequency and strikes the Earth's surface, thereby warming it. In turn the heat at the surface results in infrared radiation, which is directed back through the atmosphere. Some of the infrared radiation makes its way into space, but not all, because it has a very different frequency, which can excite the molecules of carbon dioxide and other GHGs. Because of this, a portion is trapped by the atmosphere, thereby adding warmth to the planet. The amount of infrared radiation that is trapped depends on the concentration of carbon dioxide in the atmosphere. The higher the concentration, the warmer the average temperature of the planet.

Contained within the Charney report is the following critical sentence: "We estimate the most probable global warming for a doubling of CO_2 to be near 3°C with a probable error of ± 1.5°C."

This sentence presents, in quantitative terms, what there is to fear. The technical term for the underlying concept is "climate sensitivity," and it refers to the degree to which the average global temperature of the Earth's atmosphere is sensitive to the atmospheric concentration of carbon dioxide.

As a general matter, global warming can be a good thing. The Earth would be far less hospitable to human existence if the atmosphere were colder because it did not trap infrared radiation. The fear is that the rate of fossil fuel consumption during the industrial age has produced too much of a good thing and therefore we have excessive global warming.[11]

To gain a sense of how atmospheric carbon concentration looked in 1979 when the Charney report was released, consider Figure 1. This figure displays the history of a time series of concentration levels during the past 805,000 years. You will see that, for almost the entire period, concentration levels varied between 200 and 300 parts per million (ppm). Lower concentration levels are associated with ice ages, and higher concentration levels are associated with warming periods. Carbon dioxide ppm in 1979 was 337, having breached the previous 300 "resistance level" in 1914.

[11] Our World in Data. https://ourworldindata.org/about. This is why all the work we ever do is made available in its entirety as a public good. Visualizations and text are licensed under CC BY that you may freely use for any purpose. Our data are available for download. All code we write is open-sourced under the MIT license and can be found on GitHub.

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